Ultrashort pulses of laser-accelerated relativistic electrons for radiobiology and metrology applications

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Using short laser pulses of relativistic intensity, it is possible to generate electron bunches with energies of hundreds of MeV or a total charge at the nC level. Applications of such a source require simultaneously achieving a high charge, electron directionality, and energy, as well as the ability to operate for a long period. Gas-cluster targets can meet all these requirements. We found a suitable configuration and demonstrated its applicability for two relevant applications: 1) radiotherapy of cancer and 2) measuring the duration of electron bunches. We use nitrogen clusters with a radius of 7 nm and a concentration of $2 \cdot 10^{14} cm^{-3}$. Irradiation with an intensity of $5 \cdot 10^{18} W/cm^2$ produces directed electron bunches with a thermal spectrum of up to 10 MeV and a charge of 2 nC. The efficiency of electron pulses with a peak brightness of 10^{10} Gy/s is evident within the first minute of cancer cells irradiation and is significantly higher than continuous gamma irradiation with a cobalt-60 source of the same average dose rate (2 Gy/min). In the second case, electrons simulate bunches in the accelerator's photoinjector and are used to develop the method for measuring bunch duration and jitter. The electro-optical method measures the THz transition radiation pulse generated by electrons at the plasma-vacuum interface. Prospects for further optimization of the source and its other applications are discussed.